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## THE MONIST

*Contents*

October, 1928

| | |
|---|---|
| Relativity in Logic | PAUL WEISS |
| Can Psychology Contribute to the Study of Linguistics? | J. R. KANTOR |
| A Personalistic Conception of Nature | A. K. MAJUMDAR |
| Egoism | CHARLES M. ATTLEE |
| A Critique on the Foundation of Adler's Ethical Philosophy | JOSEPH RATNER |
| The Search for Certainty | L. P. CHAMBERS |
| Neo-pragmatism and the Ways of Knowing | CHARLES W. MORRIS |
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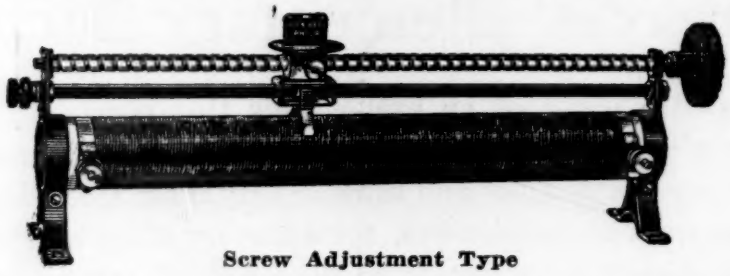

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VOL. LXVIII SEPTEMBER 7, 1928 No. 1758

CONTENTS

*The British Association for the Advancement of Science:*

*Craftsmanship and Science:* SIR WILLIAM BRAGG 213

*Joseph Edward Kirkwood:* PROFESSOR J. W. SEVERY 223

*Scientific Events:*

*The Edinburgh College of Physicians Laboratory; The Proposed International Park; The Eclipse of May 9, 1929; A Central Station for Experiments in Mining; The International Commission on Illumination; The Society of Chemical Industry* ..... 224

*Scientific Notes and News* ..... 227

*University and Educational Notes* ..... 229

*Discussion and Correspondence:*

*An Extinct Hot-spring Basin in Western Utah:* DR. MURRAY O. HAYES and PROFESSOR HARRY N. EATON. *The Effect of Ethylene upon the Vitamin B Content of Celery:* M. F. BABB. *Tuberization of Potatoes Increased by X-rays:* EDNA LOUISE JOHNSON. *The Alum Question:* DR. HENRY LEFFMANN ..... 230

*Quotations:*

*Millionth Maps* ..... 232

*Scientific Apparatus and Laboratory Methods:*

*A Method of Projection of Low-power Images:* PROFESSOR STEPHEN R. WILLIAMS. *A Practical Density Demonstration:* RALPH E. DUNBAR ..... 232

*Special Articles:*

*The Maturation and Somatic Divisions in Hybrids, Variables and So-called Mutants:* PROFESSOR E. C. JEFFREY. *High and Low Frequency Measurements with Laminaria:* DR. L. R. BLINKS. *The Absolute Zero of Internal Energy and Entropy and the Corresponding Inertness of Matter:* DR. R. D. KLEEMAN ..... 233

*Science News* ..... x

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## CRAFTSMANSHIP AND SCIENCE[1]

WHEN, nearly a century ago, the founders of our association drew up a statement of purposes and rules, they gave prominence to the words "to obtain more general attention for the objects of science." Since that time we have tried continuously to fulfil our self-imposed task, not, I hope, unwisely nor untactfully, nor without success. For this purpose we have on many occasions and in many ways endeavored to describe the progress of our researches, and to present the consequences of discoveries as they appeared to the discoverers. With your permission, I would like this evening to add something to the story. I would claim as my justification for doing so the fact that in the last few years scientific inquiry has advanced at a rate which to all is amazing, and to some is even alarming. On the one hand, the application of science to industry has become increasingly important and obvious, as was so clearly shown by our honored president of two years ago. Especially at the present time when our country is struggling to free itself from distress due partly to the war and partly to violent changes in economic conditions, is it of interest and importance to consider what science is doing and can do to accelerate recovery. On the other hand, in the less material realms the applications of recent research have aroused wide interest, as may be exemplified by the influence on philosophic thought of the new discoveries in physical science, or by the effect of last year's remarkable address from this chair.

I can not deal in the time allotted to me with all the issues that are suggested by these considerations. I propose to limit myself in a manner which my choice of title will suggest, and in speaking of "craftsmanship and science" to pay attention more particularly to the relations between science and craftsmanship of our own country. I shall not, however, be able to confine myself strictly within these limits because the entrance of science into our most material businesses can not be considered without reference to the part that science plays in the whole range of our thoughts and actions.

The term craftsmanship requires definition. I am supposing it to mean the skill which is exercised in the production of whatever is wanted for human wel-

[1] Address of the president of the British Association for the Advancement of Science, Glasgow, Scotland, September, 1928.

fare. Imagine an island so cut off from the rest of the world that its inhabitants must depend on themselves for the satisfaction of all their desires, for their food, even if they have no more to do than pick fruit from a tree, for their clothing, for their housing, and other material things. They must also find their own means of satisfying less material cravings: for if they have intelligence they will look for means of studying themselves, their neighbors and the world round about them. Their eyes and ears will ask to be used for the satisfaction of a sense of beauty in form and color and sound, and their minds will try to reach out beyond what can be seen and heard. It is impossible to proceed to the satisfaction of these desires without the handling of materials, and craftsmanship begins with the skill exercised in the handling.

What the islanders succeed in achieving by their craftsmanship may justly be described as their wages, they being their own employers. If their wages are to be raised they must somehow increase one or more of the factors on which their success depends. They must be more diligent in the discovery of materials for which a use can be found; they must become better acquainted with the properties of those materials; they must develop their constructive skill. If they are too primitive to have developed the use of mechanical power, they must do everything with their own hands, guided by their own intelligence and their own feeling for what is beautiful and fitting. At every step enter the qualities that go to make craftsmanship, as I would interpret the term. There is knowledge of materials, there is imagination, there is technical skill; perseverance is wanted, love of the work itself, sympathy with the use that is to be made of it, and with the user. Clearly, on the craftsmanship of the islanders will depend whether they have enough food to go round, enough clothes to wear, whether they have leisure for anything beyond the labor that satisfies their barest necessities.

And, of course, this isolated group of people will have some characteristic estimation of what kind of wages they want. Their energies may conceivably be devoted only to the production of things that satisfy bodily desires, or they may be bent also on nobler things. I need not consider that point as I am not trying to picture Utopia. All that this image is meant to convey is the idea of craftsmanship and its fundamental importance. Nor is the account yet complete; far from it. It is not only that the products of craftsmanship are a necessity if the islanders are to live at all; craftsmanship has a value in itself. There is in men, more in some, less in others, the natural desire to use what faculties they possess. It is a fact that love of good work and delight in successful accomplishment are powerful motives, and when satisfied are sources of real happiness. Of all the motives that sway the world these are among the purest and best.

The power to produce in plenty what is wanted is, of course, only one of the great problems that a community has to consider. There is also the endlessly difficult question of distribution, of the manner in which each working individual is to receive his share of the wages. The two problems can not be separated entirely; the means directed to the solution of one contribute to the solution of the other. But I must not attempt too much; science is in the first instance concerned with the production problem: the distribution problem follows.

Let us extend our image a little; let our island be discovered and put into communication with the outside world. An exchange of craft work sets in; the islanders discover new wants that must be satisfied and they pay for the necessary imports by exporting what they make themselves. But the exports must be made to satisfy the tastes of the outside peoples or there will be no trade. So the islanders now find that they must no longer consider their own tastes entirely; they must accommodate themselves to a more general conception which is only in part their own. It may happen that under the new conditions they become less and less self-contained. Some things which are necessary to life, such as food or clothing, may become imports, being no longer produced, at any rate in sufficient quantity, within the island itself. And now the people are very firmly tied to the rest of the world; they must give that they may receive, and they must please in order that others may be willing to take. We may say that their craftsmanship is now judged more critically: and more than ever it becomes fundamental to well-being, even to existence. The conclusion I would draw from this very simple little analogy is that a people lives on what it makes or earns and that its success depends on its craftsmanship. A people can not expect to be provided for; it has no rights.

I would ask you presently to consider the difference between the craftsmanship of an early civilization and that of our own more complicated times. But before doing so, let me say yet one or two words about the older forms.

We have a profound feeling for any example of an old craft, and for very good reasons. Among them I do not include the sentimental regret that, in some cases, a past time skill seems to have disappeared. We may be sorry, but after all it is but a receipt that has been lost and may be found again any day, if

proper search is made for it. Modern knowledge and methods of analysis are at least good for that much. Nor is the collector's pride of rarity the worthiest feeling that the old specimen inspires.

Our affection for it and the reverential care with which we handle it are due to the fact that it represents to us the labor of a people, labor into which knowledge, imagination, love of beauty, technical skill have all entered. The most of what was once used in every-day life has long disappeared; even such more durable things as houses and ships, roads and cultivations may have ceased to be. The few objects that survive must be taken as examples of what has been lost. And on the showing of the student a spirit will emerge from an old vessel as great as that which issued when the fisherman of the Arabian Nights unsealed the pot that had long been lying at the bottom of the river. It is the spirit of the bygone people that takes shape before us.

The Greek gave exquisite form to his vase and decorated its surface with equal art. He copied from the growing things of nature the adjustment of lines and surfaces which give the sense of fitness for a purpose. The outlines of his vases are so perfectly adjusted that their representation in a drawing will not bear alteration by the width of a line. That the Greek should with so much skill take lessons from what his perception made clear to him, and should with so much care choose his materials and mold them to his purpose is what we should expect from a nation that shows also in its literature a passion for justice and harmony. The fine accuracy of his line is in agreement with his delicate sense of differences in thought and words.

The Roman developed the principle of the arch, and enough remains of what he built to show the daring and the power of his work. The great arches that spanned his public buildings seem to stand for the Roman rule and law under which the whole world might find shelter and be at peace.

The sword of the Indian workman was gradually brought to its temper by an infinite series of local applications of heat alternating with the few blows that could be skilfully given while for a moment it was in the workable state. The poverty of the craftsman's appliances, the meagerness of his little fire and the scantiness of the tools with which he made his way bit by bit to his final achievement are in consonance with his life of small details ruled by overmastering ideas.

I need not illustrate further. It is indeed well known to you all that the craftsmanship of a people is an expression of the best of its very self. It is to the underlying reason that I would draw your attention now. The mind of a nation is so expressed because its craftsmanship, interpreted in its widest sense, represents its efforts to live. Under this strong compulsion the nation produces results which range from pots to poetry, and all its products are stamped alike. That which we do ourselves is as representative as a Greek vase or a Roman aqueduct or a suit of armor from Milan. The craftsmanship of a nation is its very life. Even if we consider it only in relation to the production of material things, the state of a nation's craftsmanship is an index of its health.

As a people departs from its primitive condition so also does its craftsmanship. I would ask you to consider the nature of the change. The elements of craftsmanship in its original form center round the individual. In his brain is the knowledge and imagination, in his hands is the skill, and round about him lie the materials and the tools of his craft. But as the years go by it becomes impossible that all the knowledge and all the technical skill should be found in one person, and all the tools be owned by him. The craftsman becomes an association of men, a great manufacturing firm, even, we might say, a nation, if all the members of the nation contribute through government intervention and control to the maintenance of some industry. Many hands, working in an alliance which is often unconscious, are employed in bringing a product to its finished form. It is a long step from the simple workshop of the old single-handed craftsman to the vast complex factory of modern industry.

If now we ask ourselves what has brought us to this new kind of modern craftsmanship, this dependence on machinery with its wealth of production, its clattering, bustling activity and its compelling influence on the lives of all of us, we find that one simple cause has been continuously operative. It is nothing more nor less than the urgent wish of the individual to better his own condition: and in his disinterested moods, the condition of his neighbors. The change could never have been prevented.

When Hargreaves thought that by a mechanical arrangement he could manipulate several spinning wheels at one time, and succeeded, so that he had more wages to spend on his wife and children, he was obeying a universal and natural impulse. Hargreaves's neighbors being left behind in the competition for wages, pulled his house about his ears. But in the end, they, too, found themselves to be turning many spinning wheels where formerly they had only handled one. Then they, too, had more money to spend. What other turn could things have taken under the circumstances? What happened in this isolated incident is repeated again and again in every craft, and in sequence change and change marks the road that stretches far from its beginnings.

Quite apart from all considerations as to whether the new is better or worse than the old, more beautiful or less beautiful, whether it calls out the best in man as well as the older ways, or whether it fails to do so, apart from all comparisons of this kind stands the fact that the change is due to natural impulses which will not be gainsaid. The results have to be accepted. We can not put the clock back. We can not, let us say, wipe away the great steel works of the world and replace them by thousands of individuals each with his single anvil and single hammer. We can not replace the great ships of Glasgow by a multiude of little sailing boats. The plain truth is that modern craftsmanship with all its noise and ugliness is giving food and clothing, warmth and interest to millions who otherwise must die. It is ungrateful to find fault except with sympathy. Let us try in all possible ways to mend its offenses and soften its hardships, but in all honesty let us recognize that we live on modern craftsmanship in its modern form. We are each and every one of us responsible for the present conditions as long as we insist on spending money to the best advantage.

At this point it is convenient to refer to a matter which would be of little importance if it did not seem sometimes to put modern craftsmanship in a wrong light. We are continually discovering instances of the marvelous skill of the craftsman of thousands of years ago. There is here, however, no disheartening implication, as has sometimes been asserted, that men can no longer do what was once in their power. To those who look into what goes on in a factory or a mine, in the field or on the sea, there are innumerable instances of beautiful craft work, beautiful because of their fitness for their purpose, their balance of design, their ingenuity, their history, their growth under human perseverance and thought. Every one of us can bring to mind instances of technical skill demanding imagination and intelligence as well as manipulative power which could be set alongside any instance in history. Let me name only one: Could anything surpass the drawing of fibers of quartz, finer by far than a human hair, by means of the bow and arrow? It was a feat to imagine that it could be done, to anticipate that when done it would fill so perfectly an urgent need in the construction of many important instruments and, finally, to do it.

Now we come to the point at which I would ask you to consider the relation of science to the craftsmanship which I have been trying to define. I would draw your attention to the manner in which, under the urgent drive of self-preservation, the craftsman has called scientific knowledge to his aid. Sometimes the moment has been dramatic on account of the great need of the occasion and the prompt effectiveness of the reply. When, for example, coal mining was at a low ebb because the mines were becoming water-logged and no available power was strong enough to clear them, Savery and Newcomen made use of the new discoveries respecting the pressures of gases and vapors which Torricelli and Pascal, Papin and Hooke, had just been examining and trying to explain. The steam engine thus came into being and saved the situation. And when, at a somewhat later date, your own citizen, James Watt, by further application of the same physical laws, added fresh powers to the engine, the modern steam engine came into view, with all its applications to railways and steamships and many other marvels of to-day. In 1831 Faraday, in the course of certain systematic searchings, found out the way in which one electric current could bring another into being, the so-called electromagnetic induction. With that single day's work began the whole development of electrical engineering in its innumerable forms. I need not increase the number of my illustrations.

More often it happens that scientific knowledge enters with less instantaneous and startling effect into the history of a craft. It is only when you come to consider the various details of some modern product of craftsmanship that you suddenly realize how closely every detail is connected with the advance of science and, indeed, to be more particular, with the scientific laboratory. Let us think for a moment of one of those magnificent ships for which the Clyde is famous. Let us survey its various parts in our minds. Its hull of steel recalls the great forges of Britain, and the wealth of research that has been spent in works and metallurgical laboratories on the nature and qualities of steels of all kinds, research which is still in progress. Within are the engines, turbines perhaps, or reciprocating, or it may be internal combustion engines, Diesel or others. What a range of inquiry and trial and development lies in every detail, depending always on principles of physical and chemical science, tested at every stage by instruments which are a craft in themselves! You may think of the screw and of its design. You picture the curious and most efficient thrust-block by which the force of the screw is brought to bear upon the ship, and remember that Michell lately designed it on the basis of the physical laws of liquids. You look aloft and see the wireless and are reminded that this sprang directly from the physical laboratory. Your sounding apparatus is based on your own Kelvin's designs; it may be that you have fitted your ship with the wonderful and still more recent apparatus for sounding by echo, which enables her to find the depth of water, shallow or deep, even when she is traveling at high speed. The war forced this adaptation of the laws of acous-

ties. She is sure to carry some form of refrigerating apparatus, and now we are reminded of all the investigations into the production of cold by students of science like the Frenchmen Cailletet and Pictet, by Onnes in Holland and by Dewar, whom, as befits the occasion, I will call a Scotsman rather than an Englishman. And so on, from one great feature of the ship to another, and presently from detail to detail: and you find that the whole structure is linked by innumerable ties to the research work of the laboratories. Craftsmanship in its urgent need has called upon scientific knowledge for aid, and the mighty growth is due to the response. Indeed, it is not only craftsmanship that has grown, but science itself.

If you hinder the growth of science in any way you hinder the growth of craftsmanship. Now it is an important fact that science advances over a wide front, and the various branches of it move on together, not absolutely keeping step with each other, but preserving a general line. It has been suggested that science might refrain from development in some directions or, even as our good friend the Bishop of Ripon said at Leeds last year, we might proclaim a ten years' holiday. But you can not prevent interested men from making inquiry. You can not prevent the growth of knowledge, you can not even make a selection of those points of advance which will lead to certain select classes of results. No one knows what is over the hill. The vanguard moves on without any thought of what is before it. That is why, if the march of science is to be conducted in an effective and orderly way, were it only for the purposes of industry, there must always be a certain number of laboratories or parts of laboratories where scientific research has no immediate thought of possible applications.

If I read modern industrial conditions rightly the closeness of the connection between craftsmanship and science may be illustrated in yet another way. It is, I think, a fact, and a remarkable fact, that the most active of our modern industries are those which are founded on recent scientific research. The most notable is, of course, that of electrical engineering. The year that sees the celebration of our association's centenary will witness also the ceremonies that commemorate the basic experiment of Faraday. It is difficult to sketch in a few words the great edifices that have been built upon the discovery of electromagnetic induction. We might look upon it financially and picture, as some of my hearers can do, the amount of capital involved in electrical undertakings throughout the world, electric lighting, electric transmission of power, cables and now wireless, not to mention all the minor uses to which electricity is put. The transference of matter, of intelligence, of thought, of sound, even of vision, is largely dependent on electromagnetic action. If we are not familiar with financial quantities, let us just think for a moment of the change in our lives if every electric current ceased to run; and let us realize that the whole mechanism of modern intercourse would fail and that populations born to use it would be brought to dire distress.

Though the electrical engineering industry with all its branches may be said to have its source in a single laboratory experiment, yet it has grown by the continuous adaptation of fresh streams of knowledge. The huge American corporations maintain research laboratories costing millions of pounds annually, and find that the financial return justifies their policy. The General Electric Company found that a costly research into the structure of the electric lamp repaid itself over and over again. The very important technical discoveries of Langmuir and Coolidge were consequent upon an attempt to find out what happened on the surfaces of the glass bulb and of the glowing filament. The point is that the electrical industry was not merely launched by a single discovery; it is continually guided, strengthened and extended by unremitting research.

Consider the very active motor industry. The most important of all the problems connected with the internal combustion engine is that of the nature of the explosion, the effects of varying the mixture, the movement of the gas in the cylinder before the ignition, the actual occurrences at the moment of ignition, the movement of the subsequent explosion wave. The problems are exceedingly intricate. They have been and are the subject of intense research in various laboratories in this country. The research is new and the industry is new. The construction of the engine depends on the use of alloys possessing the most remarkable properties, all of which were practically unknown until recent researches of the metallurgists brought them to light. The motor car is connected, too, with the laboratories in which chemistry and physics are applied to the study of rubber. Here again is a whole story in itself, which would tell of the work done on the intricate consequences of various kinds of mixings and of treatment, of the vulcanizing and of the use of "fillers." Not many know the story; they are only aware that motor car tires last longer than was once the case.

The aeroplane, like the motor car, has become possible because of the advent of the internal combustion engine: but it has a unique feature—its element of romance, its motion through the air. The laws of aerodynamics are becoming better known, and with every advance in their knowledge the efficiency of the aeroplane increases. Their intricacy is gradually re-

solved, but the process demands, in the first place, mathematical skill, and in the second the fascinating research that is carried on in the wind channels of our laboratories. On this splendid work the progress of the aeroplane depends. I saw not long ago in a London shop-window a colored print of a flying machine. From across the street it might easily have been taken for a drawing of a modern aeroplane; a closer view showed still the same general spread of wings, the same whirling screws, the same discharge from the exhaust, a boat not at all untrue to modern design, and wheels to bear it when on land. Moreover the proportions were quite familiar. Yet the date was 1843. For all its resemblance to the modern aeroplane, how far it was from flying not only in time but in capacity! The difference between old and new in the form and materials of the wings may not be obvious to the casual observer, but in reality a wealth of trial and calculation lies between the crude projections of the old invention and the modern machine that flies. The turn of a line in the sectional outline of the wing may make the difference between success and failure, though it is only one of innumerable and equally essential details. The scientific worker grasps the meaning of that turn, and the airman tries it out, and that is the combination which brings success at last. The point is that the construction of the flying machine is a new industry based directly on knowledge recently acquired in the laboratories and continually growing under laboratory experiment. Everything depends on this careful, well-informed concentration on essential details.

If we enter the chemical province we find that there are thriving industries based on recent scientific discovery, instances at least as remarkable as those possessing a more physical basis. The chemical industries are so many and various that even a brief summary is beyond me: yet the whole of them are of comparatively recent origin. Quantitative chemistry is little more than a century old. And the more modern and more vigorous of the chemical industries depend on very recent chemical research, as, for example, those which deal with dyes, explosives, fertilizers, rubber, artificial silk and many other things. It is the same story; the craft is based on science, and in this case very obviously so. Chemical industries are based on scientific discovery, and lean on it the whole time.

It is natural to compare the condition of the newer industries with the older industries known as basic because they have long constituted by far the major portion of the country's industrial effort and are still preeminent: coal and steel, cotton and wool. In some of these industries there is serious depression. What has the fact to do with science and scientific research?

It is obvious that we can not say of any industry or craft that its condition depends only on scientific knowledge and imagination. The difficulties of the coal trade are due in large part to the powerful cause of competition. We had a good start in the knowledge of the existence of our coal deposits and in the practice of working them, in the means of distributing coal and in methods of making use of it. We reaped our harvest. But as time went on other nations gathered way in pursuit of us; they also found coal deposits, they learnt how to work them and could even improve on our practice because they could profit by our mistakes to a greater extent than we ourselves. They had not so much old machinery to scrap. Means of transit were developed in these countries; in fact we helped to develop them, as also the industries that used the coal. Such conditions must inevitably have tended to diminish our lead. The war acted suddenly and violently in the same direction. It is reasonable, though deplorable, that the industry should find itself in difficulties. The situation is not wholly irremediable, though the older conditions can never completely return. But at least a partial retrievement is possible, and we know that various research organizations, some instituted by the state and some due to private enterprise, are grappling with the question involved. It is deeply interesting to see in what way the necessary efforts are being made, and indeed must be made.

Now, whatever is done, and in whatever way it is done, the results of such endeavor, whether related to the coal or to any other industry, depend on those relations between craftsmanship and science which I have been trying to define. I would now consider these relations from one or two separate points of view. In the first instance let me say a word concerning the general connection between science and that condition in industry which is known as mass production.

It must always be the aim of an industrial organization to devise and set going one of those systems of manufacture on a large scale with which we have become familiar in recent years. With the aid of suitably designed machinery and methods, great numbers or quantities of some article in general demand can be produced at a comparatively small running cost. Generally, however, the initial cost is heavy, for the designing of the machinery and the planting of the methods call for great experience and skill, and they demand much time spent in the acquirement of the necessary knowledge and its utilization in design. Once the process is under way it may be possible, and it seems to happen on a sufficiently attractive number of occasions, that a smooth and peaceful running of the machinery brings in the wished-for re-

turns. But every such phase of production comes to a natural end. An improved process is devised, and the new displaces the old. Or it may be a factory is set up in another country where laborers can be hired more cheaply; they may be intrinsically inferior, but that will not matter if they can be drilled into the mechanical process: and, as long as the machine runs true, the standard will not fall below a certain value. The event is in accord with expectation because men will always try to improve their productivity by the use of new knowledge or more favorable conditions, so that those who fail to recognize the principle will be left behind by those who do not. The stereotyping of some process can only be fruitful for its allotted time. Mass production is in its way splendid, ministering to the necessities and conveniences of many who must otherwise have gone without. But, if it is brought to such a pitch that its processes call for little intelligence in their working, then cheap people of little intelligence will be found, in the end, to be in charge.

The relation of science to mass production is therefore both that of builder and that of destroyer. Mass productions are temporary lulls in the movement of imagination and knowledge. Much skill and thought and care may be required to arrange for one of those quiet and profitable times; the machine is set going and for a while goes by itself. But new applications of scientific knowledge, new ideas, new processes, new machines must always be in preparation. In the parks the gardeners are always nursing fresh plants to take the place of the old, and preparing them for their useful time of flowering. And so we see the meanings of the various research organizations which have been set up in the basic industries, such as the Fuel Research Board, the Cotton, the Woolen and the Silk Research Associations, the research laboratories of the steel masters at Sheffield. Much of our hope for the future is built upon their work.

If craftsmanship, to fulfil its task of providing for the people, must be continually improving its processes, then the nation that is to be successful must possess the means and the will to improve, and here we come, I think, to a notable point. May it not be said that in this country the means exist even to a remarkable degree? Our craftsmen as a whole, including all grades, are possessed of qualities, intelligence, skill, accuracy, and so on, which make improvement possible. How could our enterprises in the past have been so often successful if this had not been so? How can we be succeeding so well in respect to the new industries of the present if the capacity is not there?

Should it not, therefore, be our policy to take advantage of our country's qualities by continually seeking for fresh industries or fresh adaptations of the old? We should not surely cling unduly to older activities when they have reached the stage in which many others have learned to do them with equal efficiency, and when we can go on to something new and, it may be, more difficult. We can, of course, bolster up old industries by political methods, and I have no wish to decry such methods as always incorrect. But clearly the best protection of all is the knowledge and skill which can enable us to produce what others must ask us for because they can not so well make it themselves.

These considerations lead naturally to a second aspect of the relations between craftsmanship and science. The improvement of craftsmanship depends in large part on the absorption and adaptation of scientific discovery. How is the process to be encouraged?

We here come to a point which must be emphasized with all possible vigor, because its importance is not always realized. Scientific knowledge and experience, if it is to be of full service, must be in direct practical contact with the problem that is to be solved. This must be clear to every one of us from actual experience. If you have expert knowledge on any subject and your advice is asked, your first instinct is, as you all know, to ask to be allowed to see for yourself. It is only when all the circumstances are clear to you in their relation to the difficulty that the solution is likely to suggest itself. And it may take much watching and patient observation before you are successful. It is the combination of actual experience with scientific knowledge that is essential. As the principle is so fundamental, I may be allowed to illustrate it by an actual experience.

It was in the early years of the war that a body of young scientific students from our universities was assembled for the purpose of testing on the battlefield the value of such methods of locating enemy guns as were already known. In their mutual discussions and considerations it became clear to them that the great desideratum was a method of measuring very exactly the time of arrival of the air pulse, due to the discharge of the gun, at various stations in their own lines. If the relative positions of the stations were accurately known it would then become a matter of calculation to find the gun position. But the pulse was very feeble; how could it be registered? Various methods were considered, and among them was one which no doubt seemed far-fetched and unlikely to be successful. A fine wire is made to carry an electric current by which it is heated. If it is chilled, for

example, by a puff of cold air, the resistance to the passage of the current increases, and this is an effect which can be measured if it is large enough. If, then, the hot wire could be made to register the arrival of the air pulse from the gun, a solution of the problem was in hand. No doubt this method occurred to several members of the company; it was certainly turned over in the mind of one of them who had had considerable experience of these fine heated wires. They had been in use about thirty years, having been employed for the measurement of temperature in many circumstances where their peculiar characteristics gave them the supremacy over thermometers of the ordinary form. But, and this was the important point, was it to be expected that the effect, though it must be there, would be big enough to see? Could the faint impulse from a gun miles away produce an obvious chill in a hot wire? On first thoughts it did not seem likely, and the suggestion lay in abeyance.

But it happened that one summer morning an enemy aeroplane came over at daybreak on a patrolling expedition. The officer of whom I have spoken lay awake in his bunk listening to the discharges of the anti-aircraft guns and the more distant explosions of their shells. Every now and then a faint whistling sound seemed to be connected with the louder sounds. The wall of the hut was of felt; it was in poor condition and there were tiny rents close to his head as he lay. The gun pulses made a feeble sound as they came through. This set the officer thinking; if the pulse was strong enough to make a sound, it might be strong enough to chill a hot wire perceptibly. So the method was proposed to the company as worth trying. It was tried, and proved to be a complete success. The sound ranging of the British armies was based upon it, with results which have already been described and are fairly well known.

It is clear that the all-important suggestion could only have been made by a man who had had scientific training and experience. That is one point of the first significance. The second is that it could only have been made by such a man actually on the spot. He could not have realized the details of the problem if he had been anywhere else.

It is worth while to consider this last point a little more closely. What precisely was the difficulty which could only be resolved by a combination of knowledge and of being on the spot? It was really the difficulty of making a true estimation of quantities. It was a question of magnitudes and measurements. Any one possessed of scientific knowledge could have said, if asked, that a gun must make an air pulse, and that an air pulse would chill a hot wire to an extent which might or might not be measurable. But there is all the difference in the world between such vague general knowledge on the one hand, and, on the other, the realization that such a method is likely to work and give the desired result. It is the difference which so often escapes attention, but every one of experience knows that it is to be reckoned among the essentials. It is so easy to talk generalities or to think of them, and so difficult to get down to the details which make the effort a success. It may be the last little adjustment of magnitudes that turns the scale, and the last step the one that counts.

Are we, then, in this country, putting our scientific knowledge into the position where it is really effective? I would draw your attention to a most interesting and important movement which is attaining a notable magnitude.

A new class of worker is growing up among us, consisting of the men engaged in research associations and industrial research laboratories throughout the country. We must place a high value on their services, for they are actually and personally bringing back with them into craftsmanship the scientific knowledge which is one of its essentials. They bring the interest and the outlook of scientific inquiry into touch with both employer and employed, and I can not but think that they may be to some extent the flux that will make them run together. For they can speak with the employer as men also trained in university and college, exchanging thought with ease and accuracy. And, at the same time, they are fellow workers with those in the shops and can bring back there some of the interest and enthusiasm which springs from the understanding of purposes and methods. It is to be remembered always that personal contact has, on the whole, thanks to the better qualities in human nature, a marvelous effect in smoothing out differences. I do not think it is unduly optimistic to welcome the growth of this new type of industrial worker because it can, being in personal intercourse with both capital and labor, supply to each a new outlook on their whole enterprise, especially as that outlook is naturally illuminating and suggestive. For, after all, this is but going back to first conditions. The primitive craftsman has been replaced by separate persons or groups of persons who have slipped away from each other almost without our realizing the fact. In the most recent times the separation has become more obvious and more dangerous, and that is why in so many directions efforts are being made to stem it. Can it be good that the workman has a part demanding little intelligence, merely the capacity to repeat? Can it be expedient that mere manipulation should be left in the shop, while design and imagination have gone into the draw-

ing office and shut the door behind them? Can it be right that the factory directorate should not be in immediate contact with the vast body of scientific knowledge?

The present number of industrial research workers is relatively small; it seems likely to increase, however, in proportion to the extent to which the province of science is better understood. The better understanding I think of as manifesting in the first place in industry itself. I am sure that here it is happily on the increase. There is also a broader view to be taken. There is a public estimation of the value of any calling which affects the numbers and the quality of those who respond.

I doubt if there is in the first place sufficient appreciation of the interests and rewards in the life of a student of industrial research. The pioneers have suffered unnecessary restrictions and discouragements, but their followers will be in better case. Surely it does not need much imagination to realize the splendid side of such work? The succession of fresh difficulties to be overcome, and of new and interesting views into the nature of things and ways of the world: the unforeseen value of results, sometimes an immediate prize, sometimes the clearing of an obstacle in a manufacturing process, never less than the discovery of facts which may some day be of use: the personal association with a living enterprise and with the human spirit behind it. And when it is realized that this kind of work is wanted badly, that it is really serviceable to the community, that there is opportunity for devotion, that it is in touch at once with human needs and with the furthest stretches of thought and imagination, it surely takes on to us the final touch of nobility.

We must remember also that the road of the student of science is still none too clear. The very methods of teaching science are a constant subject of discussion. I will say no more now than this: that the best methods must take time to elaborate, and can not be expected to have arrived at their final form. The difficulty is increased by the fact that science itself grows rapidly, and the extent of its application is only now revealing itself. That the knowledge of the immensity of nature and the study of the natural laws have an educative value is well recognized. That science can be used as an educational drill is also known and made use of. But there still remains the human side: the continuous effect of the growth of knowledge upon thought and enterprise, the realization of the immense part that science is playing in modern life and is likely to go on playing. Education by scientific instruction is still apt to lack the comprehension of the human side, without which the classroom is a dull place.

There are even some who think that science is inhuman. They speak or write as if students of modern science would destroy reverence and faith. I do not know how that can be said of the student who stands daily in the presence of what seems to him to be infinite. Let us look at this point a little more closely.

The growth of knowledge never makes an old craft seem poor and negligible. On the contrary it often happens that under new light it grows in our interest and respect. Science lives on experiment: and if a tool or a process has gradually taken shape from the experience of centuries, science seizes on the results as those of an experiment of special value. She is not so foolish as to throw away that in which the slowly gathered wisdom of ages is stored. In this she is a conservative of conservatives.

What is true of a tool or process is true also of those formulae in which growing science has tried to describe her discoveries. A new discovery seems at first sight to make an old hypothesis or definition become obsolete. The words can not be stretched to cover a wider meaning. By no means, however, is that which is old to be thrown away; it has been the best possible attempt to express what was understood at the time when it was formed. The new is to be preferred for its better ability to contain the results of a wider experience. But in its time it will also be put aside. It is by a series of successive steps that we approach the truth: each step reached with the help of that which preceded it.

Nothing in the progress of science, and more particularly of modern science, is so impressive as the growing appreciation of the immensity of what awaits discovery, and the contrasted feebleness of our ability to put into words even so much as we already dimly apprehend. Let me take an example from the world of the physical sciences. There is a problem of which the minds of physicists have been full in recent years. The nineteenth-century theory of radiation asks us to look on light as a series of waves in an all-pervading ether. The theory has been marvelously successful, and the great advances of nineteenth-century physics were largely based upon it. It can satisfy the fundamental test of all theories, for it can predict the occurrence of effects which can be tested by experiment and found to be correct. There is no question of its truth in the ordinary sense.

In the last twenty or thirty years a vast new field of optical research has been opened up, and among the curious things we have found is the fact that light has the properties of a stream of very minute particles. Only on that hypothesis can many experimental facts be explained. A wave theory is of no use in the newer field. How are the two views to be reconciled? How can anything be at once a wave and a

particle? I do not believe that I am unjust to any existing thinker if I say that no one yet has bridged the gap. Some of you who were present at the Liverpool meeting may remember that Bohr—one of the leading physicists of the world—doubted if the human mind was yet sufficiently developed to the stage in which it would be able to grasp the whole explanation. It may be a step forward to say, as we have been saying vaguely for some years, that both theories are true, that there are corpuscles and there are waves and that the former are actually responsible for the transference of energy in light and heat, and for making us see: while the latter guide the former on their way. This is going back to Newton, who expressed ideas of this kind in his "Opticks," though he was careful to add that they were no more than a suggestion.

We are here face to face with a strange problem. We know that there must be a reconcilement of our contradictory experiments; it is surely our conceptions of the truth which are at fault, though each conception seems valid and proved. There must be a truth which is greater than any of our descriptions of it. Here is an actual case where the human mind is brought face to face with its own defects. What can we do? What do we do? As physicists we use either hypothesis according to the range of experiences that we wish to consider. To repeat a phrase which I employed a few years ago in addressing a university audience familiar with lecture time-tables, on Mondays, Wednesdays and Fridays we adopt the one hypothesis, on Tuesdays, Thursdays and Saturdays the other. We know that we can not be seeing clearly and fully in either case, but are perfectly content to work and wait for the complete understanding.

And when we look back over the two centuries or so during which scientific men have tried systematically to solve the riddle of light, or even go further back to the surmisings of philosophers of still older time, we see that every conscientious attempt has made some approach to the goal. The theories of one time are supplanted by those of a succeeding time, and those again yield to something more like the first. But it is no idle series of changes, no vagaries of whimsical fashion; it is growth. The older never becomes invalid, and the new respects the old because that is the case.

Surely it is the same in regard to less material affairs. The scientific worker is the last man in the world to throw away hastily an old faith or convention or to think that discovery must bring contempt on tradition.

There is a curious parallelism here to a relation between science and industry of which I have already spoken. Just as any particular case of mass production can be regarded as a temporary condition which the growth of knowledge brings about, and in the end supersedes, so also it may be said of any law or rule or convention or definition that knowledge is both the parent and eventually the destroyer. Time devours his own children. Even if a statement retains its outward form, its contents change with the meanings attached to its terms: and change moreover in different directions when used by different people, so that constant redefinition is necessary. How much more is this the case when the contents themselves have to be added to. The distinction between truth itself and attempts to embody it in words is so constantly forced upon the student of science as to give his statements on all matters a characteristic form and expression. And this is, I think, one of the reasons why men are often needlessly alarmed by the new announcements of science and think they are subversive of that which has been proved by time.

To this consideration I may add yet one more, which may be illustrated by the same analogy. Scientific research in the laboratory is based on simple relations between cause and effect in the natural world. These have at times been adopted, many of us would say wrongly, as the main principle of a mechanistic theory of the universe. That relation holds in our experimental work: and as long as it does so we avail ourselves of it, necessarily and with right. But just as in the case of research into the properties of radiation we use a corpuscular theory or a wave theory according to the needs of the moment, the two theories being actually incompatible to our minds in their present development, so the use of a mechanistic theory in the laboratory does not imply that it represents all that the human mind can use or grasp on other occasions, in present or in future times.

The proper employment of scientific research is so necessary to our welfare that we can not afford to allow misconceptions to hinder it: and the worst of all are those which would suppose it to contradict the highest aims. Science, as a young friend said to me not long ago, is not setting forth to destroy the soul of the nation, but to keep body and soul together.

And some perhaps might say that in considering science in relation to craftsmanship I am pressing the less noble view that I am not considering knowledge as its own end. It is said that uselessness in science is a virtue. The accusation is a little obscure because it may justly be said that knowledge is never useless. If I have thought of science in relation to craftsmanship, it is because I have tried to set out the vast importance of what craftsmanship means and stands for. I have not forgotten that there are other aspects of the inquiry into the truths of nature.

Indeed, I could not carry out the lesser task without considering the whole meaning of science. And no clear line can be drawn between pure science and applied science: they are but two stages of development, two phases which melt into one another, and either loses virtue if dissociated from the other. The dual relation is common to many human activities and has been expressed in many ways. Long ago it was said in terms which in their comprehensiveness include all the aspirations of the searcher after knowledge: "Thou shalt love the Lord thy God with all thy heart and with all thy soul and with all thy strength" and "Thou shalt love thy neighbor as thyself." In the old story every listener, from whatever country he came, Parthians and Medes, Cretans and Arabians, heard the message in his own tongue. A great saying speaks to every man in the language which he understands. To the student of science the words mean that he is to put his whole heart into his work, believing that in some way which he can not fully comprehend it is all worth while, and that every straining to understand his surroundings is right and good: and, further, that in that way he can learn to be of use to his fellow men.

WILLIAM BRAGG

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## JOSEPH EDWARD KIRKWOOD

JOSEPH EDWARD KIRKWOOD was born at Cedar Rapids, Iowa, on January 24, 1872. He died suddenly, August 16, from heart failure, while engaged in research at the University Biological Station at Yellow Bay, Flathead Lake, Montana.

His mother and father were of pioneer stock, and in 1884 the family moved to Oregon to carve out a farm from the wilderness of the upper Willamette valley. He finished his preparatory and college training at Tualatin Academy and Pacific University, receiving his A.B. in 1898. A private fellowship enabled him to start his post-graduate work at Princeton University, and a graduate assistantship at Columbia University enabled him to continue his graduate study the following year. He married Ella Belinda Hoyt, of Hillsboro, Oregon, in 1901, and took her to Syracuse University, where he was an instructor from 1901 to 1904. During this period he finished the work for a master's degree at Princeton in 1902 and completed the work for the Ph.D. at Columbia in 1903. He ranked as associate professor in botany at Syracuse University from 1904 to 1907. He was made full professor and chairman of the department in 1907. During his teaching experience at Syracuse his three children, Robert Hoyt, Mary Burnette and Edward Russell, were born. During the year 1907–1908 he acted as assistant botanist with the Continental Mexican Rubber Company, Torreon, Mexico, as a member of the research staff, investigating the availability of the Guayule shrub as a source of rubber and was studying the possibility of cultivating this shrub for commercial rubber productions. The next year, 1908–9, he spent as an investigator with the Carnegie Desert Laboratory at Tucson, Arizona, carrying on research the entire year. Since 1909 he had been connected with the State University of Montana.

He came to the State University of Montana as assistant professor of botany and forestry; from 1910 to 1914 he was professor of botany and forestry, and from 1914 on was chairman of the department of botany. As chairman of the scholarship committee, chairman of the graduate study committee and as a member of the research committee he did much to build up the State University of Montana. Not only to his colleagues but to his students as well he continually urged the necessity of research as a part of the university educational program.

Despite the fact that he was faced with the task of building a department from the ground up and for many years carried the whole teaching load, he still found time for a more than creditable amount of research in his field. It is as a pioneer botanist in the northwest that he is chiefly known, and he was probably the first worker in the field of experimental forestry in the northern Rockies. His monumental work is on the trees and shrubs of the northern Rockies, the drawings for which show his infinite capacity for accuracy and artistry as well. This large work is still in manuscript, but the state university hopes to soon have it on the press; it will mean much to our understanding of the flora of this region.

From his early days at Montana he felt that the science workers of the northwest should have a scientific association of their own because they were so far removed from the science workers of the east. From its earliest days he perhaps did more than any other one man to organize the Northwest Scientific Association, serving as its chancellor in 1925 and as councilor from that time until the time of his death. His was the moving spirit behind the plans for a research laboratory and library for the science workers of the northwest, to be located as centrally as possible for the northwest, possibly at Spokane, Washington. It is to be hoped that his untimely death will not jeopardize the financing and building of such a science center.

He felt that the teaching of science in the secondary schools of the northwest was not well organized, and the members of the Inland Empire Teachers Association will testify to the fact that he did much to

make uniform the science teaching program among the secondary schools of the inland empire. The soundness of his botanical teaching is pretty well indicated by the relatively large number of his students who have gone into successful post-graduate work with other institutions. His work in the field of plant ecology, particularly as applied to forest distribution, was certainly recognized by the foresters of the northwest, if not of the whole country.

Aside from his publications his memorial will undoubtedly be the numerous botanizing expeditions which have taken him to regions practically unexplored by botanists heretofore. During the summers of 1923 and 1924 he made extensive pack-train trips into the Selway River and Clearwater River regions of eastern Idaho, regions which had not been explored except in a casual way by botanists since the days of the explorations of Lewis and Clark. During the summer of 1925 he and Dr. C. H. Clapp combined their resources and made an extensive trip into the Sun River country for the sake of geological and botanical exploration. On these trips he never spared himself, often times working far into the night and getting up early the next morning to continue on the trail. Many thousands of plants were collected on these trips and beautifully preserved and pressed.

Those who knew Dr. Kirkwood well will remember him for his enthusiasm for his work, for his kindly friendliness, and for his uncompromising stand for those things he thought and felt to be right in both the university and the community.

J. W. Severy

University of Montana

## SCIENTIFIC EVENTS

### THE EDINBURGH COLLEGE OF PHYSICIANS LABORATORY

The annual report for 1927 of the Laboratory of the Royal College of Physicians of Edinburgh has recently been submitted by the curator, Sir Robert Philip. The report, according to the *British Medical Journal,* shows the large amount of work done, both in research and in reporting. Twenty-four workers were engaged in research during the year; nine were fellows of the college, one a member of the college, six were fellows of the Royal College of Surgeons, and the remaining eight were granted places in the laboratory by the committee; their researches related to pathological, bacteriological, chemical and physiological problems. The investigation into the therapeutic value of taurine in the treatment of tuberculosis, which Takeoka believed to be considerable, has been continued, but the result of the experiments has shown that taurine, even when given in large doses, can have only a relatively slight influence. A series of experimental observations was also conducted with a view to assisting in the standardization of tuberculin. Further progress has been made in work on the mathematical theory of contagious epidemics, and the results have been published. A statistical examination of antirabic treatment in India has also been published; this work was undertaken as a study of the system of statistical representation which the League of Nations will shortly apply to the statistics of antirabic institutes throughout the world. The importance of the alkaloid harmine, to the chemistry of which much study has been devoted at the laboratory, is, the report states, increasingly recognized while work on the synthesis of benzcarbolines in general has assumed greater importance. The Chemotherapy Committee of the Medical Research Council has asked that further syntheses be carried out; samples of certain preparations have already been submitted to the committee in order that their physiological and, in particular, their antimalarial properties may be tested. Other researches, covering a wide field, have been undertaken, and a considerable amount of work had been done in the laboratory as an aid to fellows in the prosecution of research on clinical lines by preparing sections of morbid anatomy, microphotography, etc. The amount of medical reporting work, which in the case of fellows of the College of Physicians or the College of Surgeons is done gratuitously, has increased greatly. It appears that a very large amount of this type of work was done for fellows on the staff of various hospitals for the benefit of their patients. The committee has therefore considered the desirability of obtaining repayment from the hospitals for work done in this way, and a tentative appeal has been sent out to the managements concerned, showing the amount of expense incurred by the laboratory in work hitherto gratuitously done for each hospital.

### THE PROPOSED INTERNATIONAL PARK

A subcommittee of the Senate Committee on Agriculture and Forestry held a meeting in Minneapolis on August 21 to consider the possibility of establishing an International Park in northern Minnesota and the Province of Ontario, as advocated in the bill introduced in the last session of congress by Senator Shipstead. This bill contains the following provisions:

Whereas, The 14,500 square miles covered by the Rainy Lake watershed, lying in Ontario and Minnesota, and the immediately adjacent lands and waters constitute the only remaining vast wilderness area in the central part of North America; and

Whereas, This region contains the only remaining extensive coniferous forests in the Middle West with un-

usual potentialities for the development of a future continuous supply of forest products; and

WHEREAS, This region is blessed with precious international historic values, rare scenic qualities and unique recreational facilities within easy reach of one hundred million residents of both Canada and the United States; and

WHEREAS, This area affords an unusual opportunity to preserve, perpetuate, restock and increase various species of wild life of invaluable economic and esthetic importance to both nations; and

WHEREAS, Within this region two neighboring areas with similar public purposes were set aside by the respective governments in 1909 and designated, respectively, as the Quetico Provincial Park and the Superior National Forest; and

WHEREAS, Citizens of the friendly Province of Ontario have invited the cooperation of our people in protecting and augmenting the public values of this forested lakeland region; and

WHEREAS, Legislation seeking to develop a uniform plan of treatment and protection for this entire region will be of inestimable value to both Canada and the United States and will expedite the fruition of ideals and plans which the Webster-Ashburton treaty solemnly affirmed and for which the Quetico Provincial Park and the Superior National Forest were set aside; and

WHEREAS, Pending final and definite word as to the wishes of the Province of Ontario and subsequent negotiations, with the consent of the province, of a treaty between the Dominion of Canada and the United States providing for uniform treatment of the entire region, and pending further studies and final determination of desirable boundaries for the Superior National Forest and its future uses, immediate steps should be taken to extend and better protect the Superior National Forest and to protect the lands and waters in and adjacent to that portion of the area herein designated, lying within or contiguous to the United States, for the several purposes hereinbefore enumerated: therefore,

*Be it enacted* by the Senate and House of Representatives of the United States of America in Congress assembled: That all public lands of the United States situated north of township 60 north in the counties of Cook, Lake and Saint Louis, in the State of Minnesota, including the natural shore lines of Lake Superior and of the lakes and streams forming the international boundary so far as they lie within this area, are hereby withdrawn from all forms of entry or appropriation under the public land laws of the United States, subject to prior existing legal rights initiated under the public land laws, so long as such claims are maintained as required by the applicable law or laws.

## THE ECLIPSE OF MAY 9, 1929

THE Manila correspondent of the New York *Sun* writes that a total eclipse of the sun will occur there on May 9, 1929, and the Hamburg Observatory has already arranged to have an observing party in the Philippines on that date. It is expected in Manila that other parties will come from the United States and Europe.

Full information was forwarded by Father Miguel Selga, S.J., director of the Philippine Weather Bureau and the Manila Observatory, to the astronomers' meeting in Leyden. Two factors warrant the expense of sending parties, Father Selga says; first, the great probability of clear weather, and second, the duration of the total eclipse over accessible and convenient observation points.

The plane of total eclipse extends across the middle islands of the Philippines, the Visayan group, through the tenth and two thirds of the eleventh degrees of north latitude. On the western coast the duration of the total eclipse over this area will be 3 minutes 54.5 seconds; this in the vicinity of Dumaran Island, Palawan. On the eastern coast at good vantage points the duration will range between 3 minutes 42.3 seconds to 3 minutes 28.7 seconds. The longest duration of any eclipse is only about 7 minutes and such eclipses are infrequent, even speaking astronomically.

There will be places outside the Philippines, in Sumatra and Siam, for example, where the eclipse may also be observed, and while Father Selga is little familiar with the accommodations that may be found there, he thinks some of the foreign parties may choose those points. He believes, however, that all American parties should choose the Philippines, to which end he has prepared the bulletin of information on living accommodations, sites, etc., appended to his scientific data.

He says that under no circumstances should astronomers be discouraged from trying to see the eclipse of May 9, 1929, in the Philippines. He has traced back the weather on May 9 at four convenient observation points during a period of twenty-five years and finds that the chances are very great that May 9 next year will be dry and clear. The date is prior to the change of the monsoon, and, while at that season of the year there are nearly always some clouds floating about during the day, at the afternoon hour of the eclipse the sky is almost certain to be clear. He selects eastern coast points, fronting the open sea. If there are clouds they will be hovering around the mountains to the west.

## A CENTRAL STATION FOR EXPERIMENTS IN MINING

THE Senate Committee on Mines and Mining has been asked by the Chamber of Commerce and Commercial Club of Salt Lake City to endeavor to bring about the enactment of legislation to provide increased appropriations for maintenance of existing mining experiment stations throughout the United

States and to establish a central experiment station at Salt Lake City.

It is suggested that legislation be enacted as follows:

*Be it enacted* by the Senate and House of Representatives of the United States of America in Congress assembled: That there is hereby authorized to be appropriated, out of any money in the treasury not otherwise appropriated, for the expenses of mining experiment stations of the Bureau of Mines, for the fiscal year ending June 30, 1929, the sum of $327,000, in addition to the sum of $173,000 already appropriated, making a total of $500,000 for the fiscal year ending June 30, 1929; and the sum of $500,000 for each fiscal year thereafter.

*Provided:* That of the amount appropriated for the fiscal year 1929, $350,000 shall be expended for the maintenance of the seven existing mining experiment stations at Tuscaloosa, Ala.; New Brunswick, N. J.; Minneapolis, Minn.; Rolla, Mo.; Salt Lake City, Utah; Tucson, Ariz., and Seattle, Wash.; $50,000 shall be used for the establishment and maintenance of a mining experiment station at Berkeley, Calif.; $50,000 shall be used for the establishment and maintenance of a mining experiment station at Reno, Nev., and $50,000 shall be used for the establishment and maintenance of a mining experiment station at Moscow, Idaho, as authorized by the Act approved March 3, 1915 (U. S. C., Title 30, Section 8);

That the secretary of the treasury be, and is hereby, authorized and directed to enter into a contract or contracts for the erection and completion of a plant suitable and necessary for the investigations of the Bureau of Mines in Salt Lake City, Utah, the said plant to be placed on a site acceptable to the secretary of the treasury and donated to the United States Government for that purpose; the said plant to cost, complete, with the necessary railroad sidings, plumbing, lighting, heating, ventilating and other general service equipment, not to exceed the sum of $1,000,000.

## THE INTERNATIONAL COMMISSION ON ILLUMINATION

THE Bureau of Standards is one of seven organizations represented in the United States National Committee of the International Commission on Illumination, the others being the American Gas Association, the American Institute of Electrical Engineers, the Illuminating Engineering Society, the National Electric Light Association, the American Physical Society and the Optical Society of America. There are similar national committees in nine other countries—Austria, Belgium, France, Germany, Great Britain, Holland, Italy, Japan and Switzerland.

Plans are now practically complete for the seventh plenary session of the commission. This will be the first meeting of the commission on this side of the Atlantic and is being made the occasion for an International Illumination Congress, including a tour for foreign delegates to New York, Boston, Philadelphia, Washington, Cleveland, Chicago, Detroit and Niagara Falls, attendance at the annual convention of the Illuminating Engineering Society of the United States at Toronto, Canada, and special sessions of the commission at Saranac Inn, New York, from September 22 to 27.

The bureau is particularly concerned with projects of the commission affecting standard methods of photometry, international standards of candle-power, specifications for colored signal glasses and regulations for the lighting of schools and factories. Reports on these subjects have been prepared for presentation at the commission sessions.

## THE SOCIETY OF CHEMICAL INDUSTRY

THE Society of Chemical Industry is holding this week in New York an international meeting of British and American chemists arranged by the New York Section of the Society of Chemical Industry. A group of chemists and chemical engineers from England arrived in New York on Monday, September 3, and American members of the society met their British colleagues. An address of greeting was made by the chairman of the American Section, Mr. L. V. Redman.

Among the British visitors expected at the New York meeting are: Francis H. Carr, president of the Society of Chemical Industry; Sir Alexander Gibb, president of the British Institution of Chemical Engineers; Professor J. Thorpe, president of the British Chemical Society; Dr. J. A. Cranston, of the University of Glasgow; J. A. Reavell, vice-president, Institution of Chemical Engineers; Professor Hinchley, the Honorable Secretary of the Institution of Chemical Engineers, and Dr. R. T. Colgate, chief chemist of the Huntley and Palmer Company, Reading, England.

Technical meetings were to be held at the Chemists Club, 52 East 41st Street, on Tuesday, September 4, and Thursday, September 6. There was included the presidential address by Mr. Francis H. Carr. On Wednesday, September 5, the visitors were escorted by their American colleagues on a trip visiting some of the important chemical industries in New York and its neighborhood. Friday was taken up by a trip to West Point. The annual banquet of the American Section of the Society of Chemical Industry, at which the foreign visitors were guests of the Americans, was held at the Hotel Commodore on Thursday evening.

On Tuesday evening, September 4, Dr. Robert A. Millikan, of the California Institute of Technology, received the "Messel Medal" of the society, in honor of his work on the structure and relations of atoms.

Dr. Millikan responded with an address on "Available Energy."

The technical sessions of the meeting included reports on the application of glass to the chemical industries, on American production of potash, on the refining of petroleum and the characteristics of anti-knock motor fuels, on modern Duco lacquers and on chemical methods of shortening the rest period of plants.

The visitors will leave New York on September 8, the majority sailing for Liverpool by the *Celtic*.

## SCIENTIFIC NOTES AND NEWS

AT the fourth International Entomological Congress, held at Cornell University, Dr. W. J. Holland, of the Carnegie Museum, was on August 16, his eightieth birthday, by acclamation elected an honorary member of the congress. On the following day the same honor was, likewise by acclamation, conferred upon Dr. S. A. Forbes, chief of the Illinois Natural History Survey, who celebrated his eighty-fourth birthday in the spring. Dr. Holland and Dr. Forbes, who took an active part in the congress, share this honor with one other American, Dr. J. H. Comstock, of Cornell University, now in his eightieth year.

DR. JOHN J. R. MACLEOD, professor of physiology in the University of Aberdeen, has been awarded the honorary degree of doctor of laws by Western Reserve University, where he was formerly a professor in the medical school.

JOHN HAYS HAMMOND and Colonel William B. Thompson have been elected to honorary membership in the American Institute of Mining and Metallurgical Engineers. There are three other Americans who have been awarded this honor. These are Mr. Herbert Hoover, Dr. Robert H. Richards, professor emeritus at the Massachusetts Institute of Technology, and Dr. Henry S. Drinker, president emeritus of Lehigh University.

DR. EDWARD R. WEIDLEIN, director of the Mellon Institute of Industrial Research and president of the American Institute of Chemical Engineers, has been elected an honorary member of the Institution of Chemical Engineers of Great Britain.

AT the recent Dublin meeting the honorary fellowship of the Royal Institute of Public Health was conferred upon Mr. Richard Mulcary, minister for local government and public health, "in recognition of his eminent services to public health."

DR. PAUL LANGEVIN, professor of general and experimental physics in the University of Paris, has been elected an honorary member of the Russian Physico-Chemical Association. He is visiting Russia as the guest of the Society for Cultural Relations with Foreign Countries.

DR. CLEMENS PIRQUET, specialist in the diseases of children, was on August 29 nominated for the presidency of Austria to succeed President Michael Hainisch, whose term expires at the end of November. Dr. Richard Wettstein, professor of systematic botany in the University of Vienna, was the only other candidate.

DR. T. WINGATE TODD, professor of anatomy in Western Reserve University, has been appointed a member of the board of managers of the Brush Foundation, recently established in the interests of race betterment by a gift of $500,000 from Charles F. Brush as a memorial to his son.

DR. F. T. MCLEAN, plant physiologist at the Rhode Island Agricultural Experiment Station at Kingston, has resigned to become director of public education of the New York Botanical Garden.

WE learn from *Nature* that the appointments to scientific and technical departments made by the British Secretary of State for the Colonies during the month of July include two agricultural officers, Mr. A. H. Savile and Mr. N. V. Rounce, to Tanganyika Territory; one government veterinary surgeon, Mr. J. F. Timoney, to the Straits Settlements, and one veterinary officer, Mr. H. A. Hay-Barclay, to the Agricultural Department of Kenya; an assistant cotton botanist, Mr. H. R. Hosking, to Uganda; a plant breeder, Mr. E. R. Guest, to Iraq; an entomologist, Mr. R. W. E. Tucker, to Barbados, and a produce inspector, Mr. H. G. Pudney, to the Agricultural Department of Nigeria.

DR. MICHAEL F. GUYER, of the University of Wisconsin, who is spending the year on leave, expects to be in Peking, China, during the first two weeks in September and will address the Peking Society of Natural History during his visit. Dr. Guyer is accompanied by Mrs. Guyer. They expect to return *via* southern Asia and Europe.

DR. AND MRS. T. D. A. COCKERELL have returned to the University of Colorado after a journey round the world. They were recently in New Caledonia, Fiji, Samoa and the Hawaiian Islands.

DR. JOHN E. GUBERLET, associate professor of zoology at the University of Washington, has been granted a leave of absence for the autumn and winter quarters and will study at the London School of Tropical Medicine for three months. Following this he

will attend the International Congress of Tropical Medicine and Hygiene at Cairo, Egypt, from December 15 to 22. On his return he will visit the Zoological Station at Naples. He expects to return to the University of Washington by April 1, 1929.

WE learn from the *Experiment Station Record* that at the Kansas State Agricultural College at Manhattan, Dr. Roger C. Smith, professor of entomology, has been granted leave of absence, beginning on October 1, to accept a temporary appointment as entomologist in the technical service of the Department of Agriculture and Professional Education of Haiti. Leave of absence of L. E. Melchers, head of the department of botany and now serving as chief mycologist to the Ministry of Agriculture at Giza, Egypt, has been extended to January 1, 1929. J. A. Hodges, assistant professor of agricultural economics and assistant in farm organization, has been awarded one of the fellowships in agricultural economics sponsored by the Social Science Research Council and has been granted leave of absence during the coming academic year for graduate study at Harvard University.

DR. CARL VOEGTLIN, of the U. S. Public Health Service, is visiting the medical centers of Europe in connection with his investigation of radium.

PROFESSOR F. A. VARRELMAN, of the department of biology of the American University, Washington, D. C., has spent the summer months in the laboratories of the New York Botanical Garden, in continuation of his studies of the morphology and cytology of dodder, which are parasitic plants on herbs and shrubs.

DR. CARL BECK, of Chicago, secretary of the American Association of Surgeons, who is taking a trip around the world, recently inspected the medical establishments of Moscow.

PROFESSOR HANS KNIEP, director of the Berlin Institute of Plant Physiology, is returning from a visit to the Isle of Java.

PROFESSOR MARTIN H. FISCHER, of the department of physiology of the University of Cincinnati College of Medicine, spoke recently at the annual meeting of Phi Beta Kappa on "Scholarships and Main Street."

AT the Eighth Congress of the German Pharmacological Society to be held at Hamburg, under the presidency of Professor E. P. Pick, of Vienna, September 13 will be devoted to discussions of the work of the heart and vessels in honor of William Harvey, when papers will be read by Liljestrand, of Stockholm, Jarisch, of Innsbruck, Straub, of Göttingen, Anrep, of Cambridge, and Mansfield, of Pécs.

THE USSR Academy of Sciences has decided to erect a monument to the polar explorer Toll, who led several expeditions to the Arctic and perished in 1902. The monument is to be erected upon the Blizhni Lyakhovsky Island in the Arctic Ocean and will consist of a memorial tablet with an inscription and portrait.

DR. CHARLES ALFRED LEE REED, former president of the American Medical Society and until he became emeritus in 1917 professor of gynecology in the University of Cincinnati, died on August 28 at the age of seventy-two years.

CHARLES NORMAN AGETON, of Flushing, New York, a consulting chemist who for many years has maintained laboratories in Havana, Cuba, and has had an extensive practice among the sugar producers of the island, was killed in an aeroplane accident on August 15. Mr. Ageton was flying from Havana to Key West when the plane was forced down in the Gulf of Mexico. The pilots and other passengers were rescued, but Mr. Ageton was killed in the crash.

DR. CHARLES CHREE, F.R.S., superintendent of the Kew Observatory from 1893 to 1925, and president of the Section of Terrestrial Magnetism and Electricity of the International Geodetic and Geophysical Union from its organization in 1919 to 1927, died on August 12, at the age of sixty-six years. Dr. Chree was a leading authority on terrestrial magnetism, atmospheric electricity and allied subjects.

BARON ANATOLE VON HÜGEL, formerly curator of the University Museum of Archeology and Ethnology at Cambridge, died on August 15, at the age of seventy-three years.

DR. SAMUEL OPPENHEIM, since 1903 professor of astronomy at the University of Vienna, died on August 15, at the age of seventy-one years.

THE fall convention of the American Electrochemical Society will be held at Charleston, West Virginia, on September 20, 21 and 22, under the presidency of Professor Paul J. Kruse, of the New York State College of Agriculture. The secretary of the society, from whom all details can be obtained, is Professor Colin G. Fink, of Columbia University.

THE twenty-seventh annual meeting of the Society for Protection of New Hampshire Forests was held in Keene, New Hampshire, from September 5 to 7, in cooperation with the New Hampshire Forestry Commission and the New England section of the Society of American Forests. Plans for the further beautification of Franconia Notch were outlined at the meeting. Major Evan W. Kelley, forester in

charge of all national forests east of the Mississippi River, and Major George P. Ahern, former chief of the forest service of the Philippine Islands, were among the principal speakers.

ANNOUNCEMENT is made by Mr. Roy W. Crum, director, that the eighth annual meeting of the highway research board of the division of engineering of the National Research Council is to be held December 13 and 14 in Washington.

FOR the second time in the history of the Illuminating Engineering Society, the annual convention (the twenty-second) will be held outside the borders of the United States. This year the meetings will be international in character, and delegates from the old world will meet those from the United States and Canada. The meeting will be held at the King Edward Hotel, Toronto, from September 17 to 20.

UNDER a law recently signed by the president of Mexico, according to report made by the Department of Commerce, all articles will be sold by weight, measure, or volume, using metric units, and it is proposed that sales be in units or multiples of one, two or five of some metric unit, prohibiting the use of fractions.

THE United States Coast Guard ship *Marion* sailed from Sydney, Nova Scotia, on July 17 on a course through the Straits of Belle Isle northeastward into the Greenland seas. She has been fitted out for a scientific expedition to discover all she can about the behavior of icebergs from the time they break off from the Greenland glaciers until they melt in the warm waters of the North Atlantic. The *Marion* is equipped with every modern appliance for measuring the direction and velocity of deep-sea currents and for all other branches of oceanography. She is commanded by Lieutenant-Commander E. H. Smith and Lieutenant N. G. Ricketts, oceanographers, and has a crew of 20. After the loss of the *Titanic* in 1912, the United States, at the invitation of other maritime nations, established a ship patrol of the ice-regions which lie off Newfoundland in the track of the London to New York steamers.

THE daily papers report that an expedition to last for about ten months to the unexplored plateaus of central Brazil to seek traces of prehistoric colonization by tribes from Asia Minor will be undertaken in October under the leadership of J. Calvao, a Brazilian engineer. The party will carry the title of the American-Brazilian Scientific Expedition, and will receive the support of the Geographic Society of Rio de Janeiro in addition to some financial aid from the Brazilian government. The group of about twenty-six persons will search the upper reaches of the Aripuana River.

WILLIAM F. CLAPP, of Boston, has presented his extensive collection of Teredo to the Museum of Comparative Zoology of Cambridge, Massachusetts. This collection consists of several thousand specimens received from all parts of the world that were used in his studies in this commercially important group of mollusks.

## UNIVERSITY AND EDUCATIONAL NOTES

THE first unit in the two and a half million building program of the University of Tennessee is now in process of erection. The building is for physics and geology, and, with its furnishings, will cost about $300,000. Plans for a chemistry building are under way, and other buildings projected include a program calling for about $500,000 annually for the next five years.

DR. AUGUSTUS TROWBRIDGE, who for the last three years has served as the director for Europe of the International Education Board, will take up his work as dean of the graduate college of Princeton University at the beginning of the academic year. He succeeds Dr. Andrew Fleming West, who retires after a service of twenty-seven years. Dr. Trowbridge was professor of physics at Princeton from 1906 to 1925.

W. G. TAGGART, assistant director, has been appointed acting director of the agricultural experiment station and acting dean of the College of Agriculture of Louisiana University. He succeeds Dr. R. W. Dodson, who resigned in June. Dr. W. R. Perkins, director of the extension service, and Dr. E. L. Jordan, professor of animal industry, resigned at the same time as Dr. Dodson.

DR. WILLIAM D. CUTTER, dean of the New York Postgraduate Medical School, has been appointed acting dean of the school of medicine of the University of Southern California, which will open on September 17.

FREDERICK C. FENTON, associate professor of agricultural engineering in the Iowa State College, has been appointed head of the department of agricultural engineering of the Kansas State College at Manhattan, in the place of H. B. Walker.

DR. A. M. SHOWALTER, formerly national research fellow in botany and known for his work in cytology,

has been appointed assistant professor of botany in Washington University.

In the department of geology at the University of Pittsburgh the following changes are announced: Professor Henry Leighton has been appointed acting head of the department; Dr. Ransom E. Somers, formerly head of the department, who has joined the staff of the Gulf Companies, retains a lectureship; Dr. Kenneth C. Heald, staff geologist of the Gulf Companies, has been appointed lecturer; Mr. R. E. Sherrill, of Cornell University, has been appointed instructor.

Appointments made in the department of geology and geography at the University of Tennessee this year are as follows: Julia M. Shipman, who received her doctorate at Clark University in June, instructor in geography; Berlin C. Moneymaker, B.S. (Tenn.), teaching fellow in geology; A. H. Senter, assistant.

Dr. E. B. C. Mayrs has been appointed to the chair of pharmacology and therapeutics at Queen's University, Belfast.

M. Moog has been appointed professor of chemistry and toxicology in the University of Toulouse.

## DISCUSSION AND CORRESPONDENCE

### AN EXTINCT HOT SPRING BASIN IN WESTERN UTAH

White Valley, known locally as Tule Valley, western Utah, lies nearly within the confines of northern Millard County. It is a typical desert valley of 4,500 feet elevation, with playa center and Lake Bonneville shore-lines. The length north and south is about thirty-six miles and the measure of its east and west extent is twelve miles. The valley is bounded on the east by the mile-high House Range of Cambrian rocks, dipping gently eastward, and the western limit is the Confusion Range, low by comparison, whose structure and stratigraphy are little known. A recent reconnaissance by the writers shows that the Confusion Range consists of Paleozoic sediments with strong westerly dip.

The main wagon trail to Nevada in this part of Utah crosses Tule Valley west-northwesterly from Marjum Pass in the House Range to Cowboy Pass in the Confusion Range. Several prominent structural ridges occur in the valley mainly south of this road near the gentle eastern slope of the Confusion Range, one being at the intersection of the meridian of one hundred thirteen degrees thirty minutes west longitude and the parallel of thirty-nine degrees fifteen minutes north latitude. A hasty examination of the limestone here suggested to Hayes its lithologic similarity to the Cambrian of the House Range described by Walcott.[1]

Davis[2] has shown that the House Range is bounded on the west by a great normal fault. Accordingly, Tule Valley appears to be a graben, although direct proof of the presence of a westward bounding fault would be difficult to find, owing to the fan-bayed condition of the Confusion Range.

About three fourths of a mile north of the above-mentioned ridge and north of the road there occur in a direct north and south line three separate structural masses of limestone with northwesterly and westerly dips, each one several acres in extent, and about one half mile equidistant from one another. They rise about sixty-five feet above the desert floor and are isolated by the sediments of former Lake Bonneville.

The top of the southern hill is covered with fifty or more small cones of calcareous material, whose heights vary from three to seven and eight feet. The orifices have collapsed. The material around the slopes of the cones resembles the hardened mud in the geyser basins of the Yellowstone Park. Some fine large sinter cones, showing dome structure, were found on the central hill. The northern knoll has no distinct cones, but is covered with sinter. Davis[3] may have visited this northern hill or a similar one twenty-four years ago.

From the above it would seem that we have here in western Millard County a basin of hot springs of relatively recent geologic age, judging by the good state of preservation of many of the cones. Faults undoubtedly occur, as the strike of the limestone of these low hills does not coincide with their linear extent, the same being true of the larger limestone ridge south of the road. Two miles west evidence of hot springs again appears at the base of another limestone ridge and the observer can detect scores if not hundreds of similar deposits over the valley as far as the eye can reach. The writers suggest that some of the white material carried by the wind in this part of the playa owes its origin to calcareous sinter. An investigation of the region to the north might repay the effort, as the topographic map[4] shows several isolated knobs in straight alignment about eight miles north of the northernmost of the knolls above described.

[1] Walcott, C. D., "Cambrian Geology and Paleontology," No. 5. "Cambrian Sections of the Cordilleran Area," Smithsonian Misc. Coll., Vol. 53, 1908, pp. 173–185.

[2] Davis, W. M., "The Wasatch, Canyon and House Ranges, Utah," Mus. Comp. Zool., Bull., Vol. 49, Geol. Ser., Vol. 8, No. 2, 1905, pp. 46–49.

[3] Davis, W. M., *op. cit.*, pp. 36–37.

[4] U. S. Geol. Surv., Fish Springs Quadrangle, Utah. Scale, 1/250,000.

About thirty miles north-northwest of the town of Delta, Millard County, near the Juab-Millard County line, there are several hot springs still flowing and forming bodies of tufaceous material like those found in Tule Valley. These active springs are at the edge of a recent flow of basaltic lava which is several square miles in area and varies in thickness from twenty to forty feet at its edge to perhaps three or four hundred feet near the cone from which it issued. It seems probable that these springs, as well as the springs in Tule Valley, are connected genetically with the igneous activity of which there are such abundant evidences in this part of the state.

MURRAY O. HAYES
HARRY N. EATON

PROVO, UTAH
SYRACUSE, N. Y.

## THE EFFECT OF ETHYLENE UPON THE VITAMIN B CONTENT OF CELERY

THERE appeared in SCIENCE for September 30, 1927, an article entitled "Artificially Ripened Fruit" in which it was questioned whether the employment of ethylene gas to speed up the ripening process in fruits and vegetables might not result in a reduction in their food value. The following excerpt will refresh the reader's memory and express the problem:

> The food value of the tomato, ripened by the application of ethylene gas rather than through natural agencies, is under question by the American Medical Association. During the last three or four years the use of ethylene gas to ripen fruits and vegetables . . . has increased by leaps and bounds. . . . The American Medical Association points out that while this development is of vast importance commercially, the health phases of the question have as yet received little attention. Certain fruits and vegetables are recommended by physicians largely because of their vitamin content; whether or not this has been altered by ethylene has not been determined.

The results of recent experiments indicate that ethylene used in blanching celery may exert no effect upon its vitamin B content. Young rats of the same litter were paired closely as to weight and placed upon a standard vitamin-B-free ration. Ethylene and board-blanched celery, for comparison, were fed in known quantities apart from the basal ration, and check animals from each litter were maintained.

When the differences in the percentage increases in growth of paired rats were compared by Student's method, odds of 17.8:1 were found to exist in favor of the ethylene-blanched product. The odds being insignificant, it can not be concluded that either method of blanching is superior from the standpoint of conserving food value. It does indicate, however, that the treatment, under the conditions existing in this experiment, can not be considered injurious to the vitamin B content of celery.

M. F. BABB
UNIVERSITY OF MAINE

## TUBERIZATION OF POTATOES INCREASED BY X-RAYS

INCREASE in the number of tubers per hill was obtained by irradiating potatoes with one very light dose of X-rays before planting. Early Ohio potatoes from certified "seed" were used, and care was taken to select comparable pieces for both the controls and the experimental material. The irradiated tubers and controls were planted in alternating rows in the same plots of soil, so that all were subjected to the same environmental conditions with the exception of the X-ray treatment.

When the crop was harvested, it was found that 95 per cent. of the irradiated tubers had produced plants. Those irradiated before sprouting produced 27 per cent. more tubers per hill than did the controls. The average weight of these tubers, however, was 18 per cent. less than that of the controls. Consequently the average total weight of tubers per hill was practically the same for controls and experimental plants. There was no evidence that irradiation would result in an increased weight for the total crop.

A number of sprouted tubers were irradiated with a light dose of X-rays before planting and these also produced plants having a greater number of tubers per hill than the controls, but with a smaller weight per tuber.

A more detailed account of this investigation together with the results obtained by irradiating tomatoes is being prepared for publication in a botanical journal.

EDNA LOUISE JOHNSON
UNIVERSITY OF COLORADO

## THE ALUM QUESTION

I NOTE that the columns of SCIENCE have been opened to a discussion of the "alum" question. In view of the statements so frequently and widely made and the acrimonious disputings that have marked the discussion—suggesting the "war of the experts" so often seen in criminal trials—I would like to call attention to a serious neglect of correct terminology. In a recent letter in SCIENCE several statements are made in which "alum" is put for "aluminum." Thus, it is said on page 162 (August 17) that the chemists of the Department of Agriculture have found the quantities of alum in our agricultural food products "extremely minute." The quantities of "alum" in these foods will be represented by 0.0.

In these discussions which cover hundreds of pages and have cost in expert and lawyer fees thousands of

dollars, little, if any stress is laid on the fact that after the dough is made up, there is no "alum" in the mass. All baking powders have an excess of carbonate and the whole of the aluminum sulphate is converted into aluminum hydroxide. In the discussion of the wholesomeness of alum baking powders some attention might be given to the question of the comparatively large amount of sodium sulphate that is introduced into food by such use. The right of crystallized sodium aluminum sulphate to be called "sodium alum" is set forth in some detail in a paper published in the June issue of the *Bulletin* of the Wagner Free Institute of Science, of Philadelphia, and reprinted in *The American Journal of Pharmacy* for July, 1928.

HENRY LEFFMANN

AUGUST 20, 1928.

## QUOTATIONS

### MILLIONTH MAPS

THE geographers of the world assembled at Cambridge, England, have agreed that the mapping of the heavens is to be an international undertaking. They have also decided that an airman's map of the world shall be made on the scale of 1 in 200,000, which is just over three miles to the inch. This map is to show all landmarks that are prominent from the air, such as rivers, shores, railroads and forests. When the thirty nations that are cooperating in making this birdseye view of the world have finished their task, it will be possible for the aerial tourist to find his way without much more difficulty that he has in an automobile on land. For some reason best known to the geographers it has been decided to use Mercator's projection, which has taught the world an exaggerated idea of the area and shape of the northern portions of this hemisphere. An interesting innovation is the abandonment of the old system of reckoning latitude north and south of the equator and longitude east and west from Greenwich. In its place the new system is to be used of reckoning latitude from the South Pole 180 degrees to the North Pole, and of carrying longitude all the way round the globe from Greenwich.

One of the subjects which the geographers have been discussing is the work on the so-called "Millionth Map," which is to show the world and all that is upon it on a scale of 1 to 1,000,000, which means about sixteen miles to the inch. This project was first broached thirty years ago by the German geographer, Professor Penck. In 1909 at a meeting attended by representatives from various nations it was agreed that each nation should contribute maps of its own territories. A central bureau to supervise the work was established in Southampton and the European sections were at once begun.

Unfortunately, the United States has been slow in performing its part. As usual, the blame is laid to lack of funds. Of the forty-five sheets covering the United States only four have been completed, despite the efforts of the United States Geological Survey, which has charge of the work, to arouse public interest in order to bring pressure to bear on Congress to provide the money. In the meantime the American Geographical Society has been working on its "Millionth Map" of South America, and is turning out a piece of splendid workmanship. These maps may serve as part of the contribution of the Hispanic countries to the world map. Made with exceptional accuracy, they are examples of cartography which compare favorably with the work of the Swiss, German, French and English.

It may be the vast area of this country which has hampered American map-making. Compared to the maps made by any of the above-named European governments, the average American map is incomplete and unsatisfactory. In fairness to the United States Geological Survey, it must be said that the men directing the work and in the field are highly skilled and competent. But the failure of the government to improve its early surveys, and to revise the base maps at least every decade, has resulted in the maps being not only frequently misleading but also actually deficient in recording changes such as roads, railroads, bridges and shifting coast lines. It is time not only to hasten completion of the Millionth Map but also to make it possible for the Geological Survey to issue maps which will stand comparison with those of Europe.—*The New York Times.*

## SCIENTIFIC APPARATUS AND LABORATORY METHODS

### A METHOD OF PROJECTION OF LOW POWER IMAGES

IN the laboratory one often wishes to draw an accurate outline of a somewhat large object. This can be done with an elaborate and often expensive drawing outfit which seldom is permitted to stand in a usable condition because of the space it takes.

I have used a simple lens with a camera lucida attached to it (very insecurely) and I have used a compound microscope with an objective of three-inch focus and the stage lowered because the rack and pinion was not long enough to permit focusing the lens on an object on the stage in its normal position. The objective may also be screwed to the end of the

draw tube and so be raised to a level at which it may be focused. In this case the nose-piece must be removed.

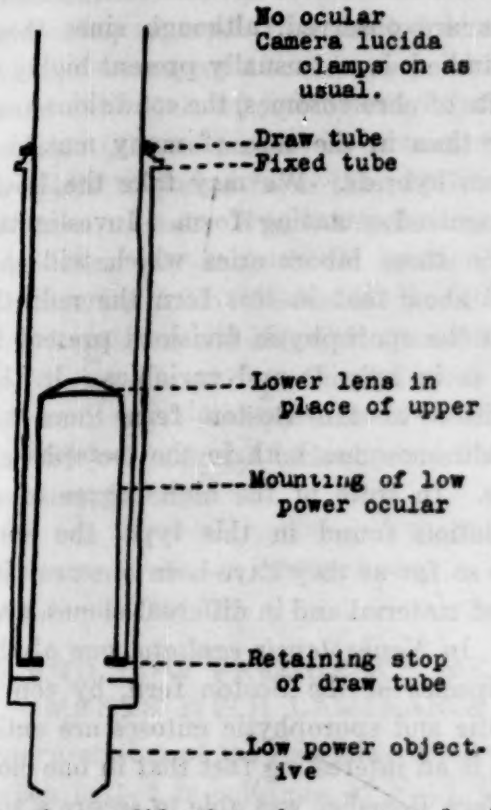


Diagram of a modification of a compound microscope for projecting low power images with the camera lucida. The stand and rack and pinion are not figured.

These methods lack firmness or adaptability and were always makeshifts.

I found an ingenious student last year using a combination which enabled him to get any magnification from ten to thirty diameters he pleased. I do not give the make of the microscope he was using, for I think any instrument with a draw tube can be used.

He took the long (low power) ocular and unscrewed the lenses, replacing the upper lens by the lower and discarding the upper lens. Then he unscrewed the draw tube, removed the retaining stop at the lower end of the draw tube, placed the modified ocular, lens upward, in the draw tube, screwed back the stop and replaced the draw tube in the microscope. He used no upper ocular but focused the instrument in the usual way. When the image was distinct he was able to increase its size by pulling out the draw tube and focusing again. I think a microscope that is constructed for 160 mm tube length will not be clear until that length is reached, but beyond that the image will be increased in size as the draw tube is lengthened.

With a camera lucida he was able to project section after section of a 10 mm pig series at sizes of ten and thirty diameters and all between.

This method may not be sound optically, but it gives clear images, increases the range of effective use of the compound microscope, and I wish I had known of it forty years ago.

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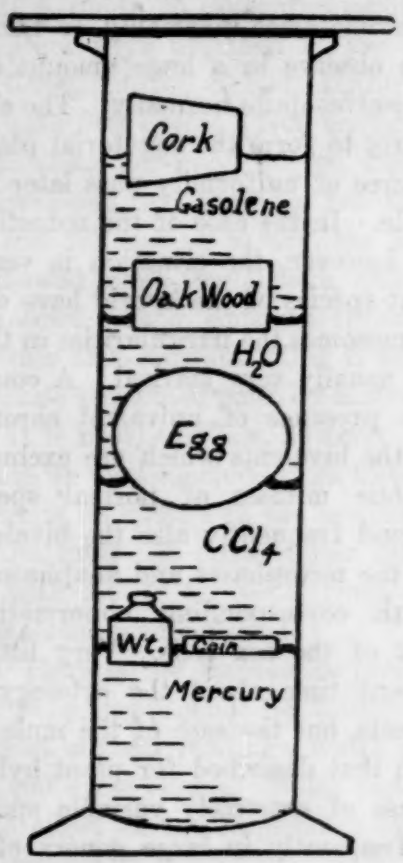
## A PRACTICAL DENSITY DEMONSTRATION

THE differences in density of various liquids, the non-miscibility of these liquids and their buoyancy as expressed by Archimedes can be rather vividly demonstrated by use of the simple apparatus illustrated herewith. The liquids contained in an ordinary




hydrometer jar are mercury, carbon tetrachloride, water and gasolene, each added carefully in turn to the vessel. Objects are added as each layer of liquid is introduced. These may include a brass weight and coin, egg, piece of oak wood and cork which will float on the several layers of liquid, respectively. Gold or platinum articles will also sink in the mercury if added. When once this piece of apparatus has been arranged, it may be preserved for months, with the possible exception of the egg.

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# SPECIAL ARTICLES

## THE MATURATION AND SOMATIC DIVISIONS IN HYBRIDS, VARIABLES AND SO-CALLED MUTANTS

AN important feature in hybrids, which obviously has not attracted the attention which its significance demands, is the striking difference between the conduct of the chromosomes in the meiotic and somatic

(sporophytic) divisions. The present writer in his own work and that of his students has passed under review an enormous amount of material of hybrids, extremely variable species and so-called mutants. The technique of the mass method makes it possible to multiply almost indefinitely the material for observation, since many stages of the same material may be sectioned and stained simultaneously.

In known hybrids the contrast between the conduct of the chromosomes in the reduction division and in the divisions of the body cells is very marked. In the latter, the chromosomes invariably, so far as we have been able to observe in a huge amount of material, conduct themselves quite normally. The chromosomes move regularly to form the equatorial plate and with the same degree of uniformity pass later to the poles of the spindle. In the case of the reduction divisions of hybrids, however, the situation is very different. If the parent species of the hybrid have diverse numbers of chromosomes the irregularities in the reduction division are usually very marked. A common occurrence is the presence of univalent chromosomes, in addition to the bivalents which are exclusively found in the meiotic mitoses of normal species. These univalents, and frequently also the bivalents as well, lag both in the metaphases and anaphases of nuclear division with corresponding abnormalities in the development of the sex cells. Very little is known at the present time about the cytology of hybrids among animals, but the case of the mule corresponds exactly with that described for plant hybrids.

In the case of extremely variable species such as are found frequently in large genera of plants, the divisions of the body cells and the reproductive cells in general present the same features as are found in known hybrids, whether plants or animals. The genus Rosa has been widely investigated in regard to its reduction divisions and a number of striking abnormalities have been described in the various species of the Canina section and to a less extent in other sections. Although these abnormalities appear strikingly where the number of chromosomes is an uneven multiple of the seven characteristics of the genus they are also found to a less extent in the case of even-multipled polyploid species. It does not, however, seem to have been noted that the sporophytic divisions in these highly variable roses are quite normal, even when the reduction divisions present extreme departures from the usual type. Investigations in this laboratory on the genus Crataegus, on the Rubi of the Eubatus section, etc., show that this contrast in the conduct of the chromosomes in the sexual and sporophytic cells is found equally in other large and variable rosaceous genera. Extensive investigations on grasses, sedges, Betulaceae, Eucalypta, acacias, Proteaceae, etc., show that this is the usual state of affairs in highly variable species.

In the case of the so-called mutable species similar conditions are observed, although since those as at present studied do not usually present highly complex equipments of chromosomes, the conditions are slightly less clear than in the case of many mutable species and known hybrids. We may take the Boston fern as a recognized mutating form. Investigations carried on in these laboratories which will shortly be published show that in this fern the reduction divisions and the sporophytic divisions present the same contrast as in hybrids and variables. In the reduction division of the Boston fern there are many lagging chromosomes both in the metaphase and the anaphase. In spite of the high degree of clonal or bud variation found in this type, the sporophytic divisions so far as they have been observed in a large amount of material and in different clones, are entirely normal. In *Nephrolepsis exaltata,* one of the known parent species of the Boston fern, by contrast both the meiotic and sporophytic mitoses are entirely normal. It is an interesting fact that in one clone of the Boston fern Benedict was able to secure a small number of viable spores. When these germinated they gave rise to an extremely varied progeny, thus presenting further reason for regarding the Boston fern as a hybrid derivative of *N. exaltata.*

In *Oenothera Lamarckiana* and other variable Oenotheras the same situation presents itself. On account of the relatively infrequent multiplication of the chromosome numbers in so-called mutating Oenotheras the abnormalities in the reduction division are less frequent, although they have been described by nearly all those who have worked on the cytology of Oenothera. The most marked abnormalities in the sexual divisions are apparently found in those individuals which present in the highest degree the sterility which is more or less characteristic of all species of Oenothera. The Daturas also appear to be characterized by similar abnormalities, especially in the case of individuals with uneven multiples of chromosome equipment.

The so-called mutating species most in the eye of biologists at the present moment is *Drosophila melanogaster.* The somatic divisions of this species normal and polyploid have been admirably described by Professor Morgan and his associates. Unfortunately, however, they have furnished no descriptions of the obviously highly significant male meiotic mitoses of this species. As a result of the examination of a huge amount of material, investigated with the advantage of the mass method, it becomes obvious that the

male meiotic phenomena in the male gonads of *D. melanogaster* are strikingly similar to the reduction divisions in known hybrids, whether plants or animals. The abnormalities of the maturation division in this species, so much investigated by too purely experimental means, seem to show beyond any reasonable doubt that it is of hybrid origin. This is the more obvious because meiosis in certain other species of Drosophila to judge from the published descriptions is quite normal. It seems unfortunate that the experimentalists *pur sang* should in the main choose for investigation such freaks as the Boston fern, species of Oenothera and above all *Drosophila melanogaster*. The results of experimental work would apparently be much more permanent and convincing were the subject material less abnormal than in the cases mentioned above.

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## HIGH AND LOW FREQUENCY MEASUREMENTS WITH LAMINARIA

AN interpretation of the resistance changes in *Laminaria* when bathed in solutions of NaCl, $CaCl_2$, etc., is of importance in the theory of permeability. Several possibilities exist beside alteration of the ionic permeability of the protoplasm.

(1) There may be a change in the specific resistance of the intercellular substance corresponding to its well-known hardening in calcium and the softening in sodium salts. (2) The specific resistance may remain constant while the cross section expands or contracts, as observed by Kotte in the walls of algae. Or (3) a change in the electrical capacitance of the cell surface might alter the effective impedance of the whole system.

None of these interpretations is clearly indicated by measurements taken at one frequency only, so that it seemed desirable to extend the readings made at 1,000 cycles by Osterhout,[1] both to zero frequency and to very high frequencies, in order better to locate the seat of change.

Direct current measurements were made by using magnesium metal ribbons dipping into the sea water of the electrode cups. (The Osterhout apparatus was used for holding the column of *Laminaria* discs. Sea water was kept in the end cups while the discs were bathed in various solutions.) These ribbons acted as reversible electrodes to the magnesium ions, which are present in the sea water in sufficient number to carry small currents without much polarization. They were likewise balanced by another pair of similar electrodes in the adjacent arm of the bridge.

The $CaCl_2$ curves of Osterhout were nicely duplicated with this apparatus and the direct current readings agreed exactly with 1,000 cycle ones taken alternately with the same electrodes. At 40,000 cycles the readings were about 20 per cent. lower, at the highest point, and nearly the same at death.

For very high frequencies a thermocouple ammeter-voltmeter apparatus was employed through the kindness of Dr. Kenneth S. Cole, who made the measurements. Values were obtained at the following frequencies: 6,000, 13,750, 45,500, 115,500, 375,000, 1,090,000, 10,800,000 cycles. Not enough points were obtained to construct good curves, but the essential fact was developed that while the low frequency readings rose and fell during injury, the high frequency readings showed much less change, and at $10^7$ cycles the values were nearly constant through the whole run. Whether this constant value is actually that of the dead ohmic resistance must be answered by future research. It is nearly as low, however.

Meanwhile we may conclude from these results that:

(1) There is no change in the specific conductivity of either the inter- or intracellular material during treatment with $CaCl_2$ or NaCl, since the high frequency value remained constant.

(2) The changes in impedance are not due to changes of capacitance since the latter would not affect the direct current readings, which agree entirely with the 1,000 cycle values. What capacitance there is has little effect on the impedance except at much higher frequencies.

(3) Changes in cross section may occur but are not sufficient to explain the results.

We may therefore hold to the interpretation advanced by Osterhout that the observed resistance change is really a change in the permeability of protoplasm to ions. Since the resistance may rise 60 per cent. or more above the normal value in seawater, it is evident that there must be considerable ionic exchange in the normal state. The reconcilement of this fact to the relatively low permeability of *Valonia* and *Nitella* to ions is a task toward which present experiments are directed.

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## THE ABSOLUTE ZERO OF INTERNAL ENERGY AND ENTROPY, AND THE CORRESPONDING INERTNESS OF MATTER

THE controllable internal energy and entropy of a substance or mixture, which varies with the volume v and absolute temperature T, the writer has shown

[1] Osterhout, W. J. V., "Injury, Recovery and Death, in Relation to Conductivity and Permeability," Philadelphia and London, 1922.

to be zero according to thermodynamics when the substance is at $T=0$ under its vapor pressure, which is zero, and that besides the adiabatic of zero entropy corresponds to $T=0$ (*J. Phys. Chem.* 31, 747, 937 (1927)). In the deduction the theorem (deduced thermodynamically) was used that the specific heat is a positive quantity. A simple proof of this theorem which depends only on our fundamental notions of heat is given in a letter by the writer in the March number of the *Philosophical Magazine,* and the deduction of the above results is thus rendered simpler and more straightforward. Experimental evidence of the truth of these results is afforded mainly by the important investigations of G. N. Lewis and his associates on the third law of thermodynamics, which is included in these results.

The above zero corresponds to minimum values of the quantities involved, and hence by the help of the axiomatic notion that the minimum does not involve discontinuities, a number of differential properties were deduced by the writer (*J. Phys. Chem.*, 31, 747; 937, 1559 (1927)). It may be pointed out that the same notion is tacitly involved in Gibbs' investigation of phase equilibrium. One of the properties deduced is that the first differential coefficient of the internal energy with respect to the temperature, or the specific heat, is zero at $T=0$. This corresponds to Nernst's theorem, and hence all the experimental evidence of this theorem is also evidence of the soundness of the deduction of the foregoing results. Another important result is that the differential coefficient of the specific heat is zero. This is sustained by the experiments of Kammerlingh Onnes on the specific heat at low temperatures, and the theoretical investigations of Einstein and Debye on the connection between specific heat and quanta. We may therefore regard the above results as fairly well established theoretically and experimentally; further experiments would be most desirable in the case of mixtures.

A set of the differential properties obtained express that the first and second differential coefficient with respect to the temperature of the internal energy, pressure and volume of a condensed substance at $T=0$ initially under its vapor pressure, are each zero corresponding to the volume or pressure being kept constant, or to the substance being kept under its vapor pressure. Some of these results will be shown in a subsequent paper to hold for other states at $T=0$. Thus the properties of the specific heat mentioned also hold for a substance in the vaporous state at $T=0$. Matter thus possesses *a remarkable inertness to temperature changes at $T=0$.* This suggests that *at $T=0$ an atom differs considerably in nature from that it has at higher temperatures,* this difference being no doubt associated with *a change in electronic configuration.*

This is further suggested by the remarkable properties deduced by the writer (May number of *J. Frank. Inst.*) that at $T=0$ the internal heat of evaporation L is zero, and that a substance in the gaseous state at $T=0$ possesses an abnormally large specific heat which may amount to thousands of calories per gram. These results may be explained by supposing that during evaporation an atom undergoes a change in electronic configuration which gives rise to a decrease in internal energy equal to the work done against the atomic forces of attraction over repulsion, and that on heating the vapor an approximately equal increase in internal energy takes place, and a corresponding reversal of the change in electronic configuration. That a substance may become unstable and explode near $T=0$ (*J. Phys. Chem.*, 31, 1669, (1927)) indicates the possibility of electronic rearrangements taking place which give rise to large atomic forces of repulsion.

Another proof that $L=0$ at $T=0$ may be given here, and that there is an associated abnormally large specific heat of the vapor. On multiplying the well-known thermodynamical equation

$$\left(\frac{\partial U}{\partial v}\right)_T = T\left(\frac{\partial p}{\partial T}\right)_v - p$$

by $\partial v$, where U denotes the internal energy and p the pressure, and integrating, it may be written

$$L = T\frac{\partial}{\partial T}\int p.\,\partial v - \int p.\,\partial v$$

But $\int p.\,\partial v = \sum MRT$, where M is a constant, and hence the right hand side is zero when $T=0$. This result combined with an equation obtained by a simple thermodynamical cycle (May number *J. Frank. Inst.*) gives

$$C_\infty - C = \frac{L_m}{T_m}$$

where $L_m$ is a finite value of the internal heat of evaporation at the temperature $T_m$ near $T=0$, and $C_\infty$ and C are the *average* specific heats of the vapor and condensed substance respectively over the range $T_m$. Thus $C_\infty$ has a value of the order of 10 or 100 cals, and is one of the abnormal specific heat effects associated with a vapor close to $T=0$. It is not unlikely that C may occasionally have an abnormally large value close to $T=0$, but at present its existence has not been proved thermodynamically nor found experimentally.

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